# CLAIMS

**WE CLAIM:**

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1.      A process for creating a broadly tunable Distributed Bragg Reflector (DBR) structure with a low spontaneous recombination rate at operating temperatures

6      comprising the steps of:

creating a first cladding layer of a first conductivity type;

creating an optical waveguide disposed on top of said first cladding layer

9      comprising the steps of creating one or more hole confinement regions and

creating one or more electron confinement regions wherein energy barriers of

greater than the thermal energy, kT, separate adjacent confinement regions;

12      creating a second cladding layer of a second conductivity type disposed on

top of said optical waveguide.

2.      The process of claim 1 further comprising the step of creating a grating layer.

15      3.      The process of claim 1 wherein:

a conduction band energy barrier greater than the thermal energy, kT, is

created by establishing an effective conduction band offset between adjacent

18      confinement regions;

a valence band energy barrier greater than the thermal energy, kT, is

created by establishing an effective valence band offset between adjacent

21      confinement regions;

the band gap of said first cladding layer and the band gap of said second cladding layer are greater than the effective band gaps of said hole confinement

24    regions;

the band gap of said first cladding layer and the band gap of said second cladding layer are greater than the effective band gaps of said electron

27    confinement regions;

a first cladding layer conduction band energy barrier greater than the thermal energy, kT , is created by establishing an effective conduction band offset

30    between the conduction band of said first cladding layer and the conduction band of the adjacent confinement layer;

a second cladding layer conduction band energy barrier greater than the thermal energy, kT , is created by establishing an effective conduction band offset

33    between the conduction band of said second cladding layer and the conduction band of the adjacent confinement layer;

a first cladding layer valence band energy barrier greater than the thermal

36 energy, kT , is created by establishing an effective valence band offset between the valence band of said first cladding layer and the valence band of the adjacent

39    confinement layer; and

a second cladding layer valence band energy barrier greater than the thermal energy, kT , is created by establishing an effective valence band offset

42    between the valence band of said second cladding layer and the valence band of the adjacent confinement layer

4.      The process of claim 1 wherein said first cladding layer comprises an n-type

cladding layer and said second cladding layer comprises a p-type cladding layer.

5.      The process of claim 1 wherein said first cladding layer comprises a p-type

cladding layer and said second cladding layer comprises an n-type cladding layer.

6.      The process of claim 3 wherein a valence band energy barrier greater than twice

the thermal energy, 2kT, is created by establishing an effective valence band offset

between adjacent confinement regions.

7.      The process of claim 3 wherein a conduction band energy barrier greater than

twice the thermal energy, 2kT, is created by establishing an effective conduction band

offset between adjacent confinement regions.

8.      The process of claim 3 wherein a cladding conduction band energy barrier equal

to greater than twice the thermal energy, 2kT, is created by establishing an effective

conduction band offset between the conduction band of said first cladding layer and the

conduction band of the adjacent confinement layer.

9.      The process of claim 3 wherein a cladding conduction band energy barrier equal

to greater than twice the thermal energy, 2kT, is created by establishing an effective

conduction band offset between the conduction band of said second cladding layer and

the conduction band of an adjacent confinement layer.

10.     The process of claim 3 wherein a cladding valence band energy barrier equal to

greater than twice the thermal energy, 2kT, is created by establishing an effective valence

band offset between the valence band of said first cladding layer and the valence band of

the adjacent confinement layer.

11.     The process of claim 3 wherein a cladding valence band energy barrier equal to greater than twice the thermal energy, 2kT, is created by establishing an effective valence band offset between the valence band of said second cladding layer and the valence band of the adjacent confinement layer.

12.     The process of claim 3 wherein the step of creating said broadly tunable DBR comprises creating one or more graded layers.

13.     The process of claim 12 wherein said first cladding layer comprises one or more graded layers.

14.     The process of claim 12 wherein said second cladding layer comprises one or more graded layers.

15.     The process of claim 12 wherein said optical waveguide comprises one or more graded layers.

16.     The process of claim 12 wherein said graded layer varies in composition across the thickness of said optical waveguide.

17.     The process of claim 12 wherein said graded layer varies in energy band structure across the thickness of said DBR.

18.     The process of claim 12 wherein said graded layer varies in composition across the breadth of said DBR.

19.     The process of claim 12 wherein said graded layer varies in energy band structure across the breadth of said DBR.

20.     The process of claim 3 wherein the thickness of said optical waveguide is selected to support a single optical mode.

21.    The process of claim 3 wherein said optical waveguide comprises one electron confinement region and one hole confinement region wherein said electron confinement layer comprises a layer of material of uniform composition and said hole confinement layer comprises a layer of material of uniform composition.

22.    The process of claim 3 wherein said optical waveguide comprises one electron confinement region and one hole confinement region wherein said electron confinement layer comprises a layer of material of uniform energy band structure and said hole confinement layer comprises a layer of material of uniform energy band structure.

23.    The process of claim 3 wherein adjacent confinement regions comprise layers of lattice matched materials.

24.    The process of claim 23 wherein said electron confinement regions comprise InGaAsP material lattice matched to InP and said hole confinement regions comprise InGaAlAs material lattice matched to InP.

25.    The process of claim 23 wherein said electron confinement regions comprise InGaAsSb material lattice matched to InP and said hole confinement regions comprise InGaAlAsSb material lattice matched to InP.

26.    The process of claim 3 wherein the thickness of said electron confinement regions is greater than the thickness of said hole confinement regions.

27.    The process of claim 3 wherein the effective conduction band offset between adjacent confinement regions is greater than the effective valence band offset between adjacent confinement regions.

28.    The process of claim 3 further comprising the step of creating one or more graded layers disposed between said optical waveguide and said first cladding layer.

29.    The process of claim 3 further comprising the step of creating one or more graded

layers disposed between said optical waveguide and said second cladding layer.

30.    The process of claim 3 further comprising the step of creating one or more graded

layers disposed between adjacent confinement regions.

31.    The process of claim 1 further comprising the step of creating one or more

additional cladding layers.

32.    The process of claim 1 wherein said energy barriers are created by band gap

tilting wherein:

said optical waveguide comprises a layer of graded material wherein the

energy level of the lowest conduction band of said waveguide increases across the

thickness of said waveguide, the energy level of the highest valence band of said

waveguide increases across the thickness of said waveguide and the energy band

gap of said waveguide varies across the thickness of said waveguide;

the changes in said energy levels creates an electron confinement region in

said optical waveguide comprising a region wherein said energy level of the

lowest conduction band and the adjacent cladding layer forms a local minimum in

the conduction band;

the changes in said energy levels creates a hole confinement region in said

optical waveguide comprising a region wherein said energy level of the highest

valence band and the adjacent cladding layer forms a local maximum in the

valence band;

132  the average band gap of said optical waveguide is greater than or equal to the carrier concentration in said optical waveguide divided by twice the thickness of said optical waveguide.

135  33.  The process of claim 32 wherein:

said optical waveguide comprises one or more layers of material wherein the energy band structure varies across the breadth of said waveguide.

138  34.  The process of claim 32 wherein said conduction band and said valence band of said graded layer comprise sloped, stepped or curved profiles across the thickness of said optical waveguide.

141  35.  The process of claim 32 wherein the materials composition of said graded layer comprise sloped, stepped or curved profiles across the thickness of said optical waveguide.

144  36.  The process of claim 32 wherein said conduction band and said valence band of said graded layer comprise sloped, stepped or curved profiles across the breadth of said optical waveguide.

147  37.  The process of claim 32 wherein the materials composition of said graded layer comprise sloped, stepped or curved profiles across the breadth of said optical waveguide.

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Broadly Tunable Distributed Brag Reflector Structure Processing          NOVA-P022